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CREATING AN INTELLIGENCE INFRASTRUCTURE FOR INTELLIGENT ORGANIZATIONS

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Abstract

Intelligence plays a significant role in biological life's survival and prosperity. Similar role of intelligence is found in organizations. As the society progresses from the industrial age to the information age, creating, nurturing, and adapting organizational intelligence have become increasingly important. The proposed research will lead to a framework of integrating advanced information technology into organizational design that aims at improving organizational intelligence.

Introduction

Modern information technologies has led to dramatic changes in the way businesses operate, compete, and serve their customers, enabling them to streamline their operations and to become more effective in their quest for creating value for their customers (Applegate et al., 2002). The Internet and the Worldwide Web have fundamentally changed our society, offering both opportunities and challenges. Today's enterprises must go beyond traditional goals of efficiency and effectiveness; they also need to be intelligent in order to adapt and survive in an increasingly competitive environment (Liebowitz, 1999). Those enterprises that learn and adapt continuously to the changing environment are referred as intelligent organizations. Stonier (1991) suggested that intelligent organizations must have not only intelligent individuals, but also "collective intelligence" that is created through integration of intelligence from sub-units of the organization. Quinn, Anderson, and Finkelstein (1996) called for designing organizations around intellect. Intelligent organizations need to design and build organization structures around intelligence, as opposed to traditional approaches that focus on products, processes, or functions (McMaster, 1996; Liang, 2002).

Theories of organizational learning and organization design abound (see Galbraith, 1977; Jones, 1996; Malone, 1997; and Wang and Amed, 2003). The literature on integrating information technology with organizational intelligence is relatively sparse. Huber (1990) recognized the need to review and revise certain components of organization theory in light of recent development of advanced information and communication technologies. In the form of a series of propositions, Huber set forth a theory of the effects of advanced information technologies on organizational design, intelligence, and decision making. Mentzas (1994) looked at impact of information technology on organizational decision making. Traditional computer-based information systems are effective at certain parts of organizational support, but lack the adaptive and integrated support needed by intelligent enterprises.

In this study, we will re-examine concepts and theories of information technology and information systems through the lens of organizational intelligence. With this re-examination and conceptualization, we hope to develop a framework of information technology and information system based organizational intelligence. While the far-reaching nature of organizational intelligence research requires the concerted effort from disciplines such as management, psychology, social science, information systems, and computer science, we will focus our endeavor on the study of using information and communications technology to create an intelligence infrastructure that is essential in building and sustaining organizational intelligence.

Information Concepts and Intelligence

Modern information technology was born with the arrival of computers. Various information systems have been developed over the last 50 years (see Mentzas, 1994 for a good review of information systems and components of information systems). Information systems have traditionally been designed around functionalities. For example, transaction processing systems for data

processing, management information systems for operational level managerial support, and decision support systems for solving unstructured problems at tactic and strategic management level (Stair and Reynolds, 2003). Researchers as well as practitioners in recent years have recognized the need for organizational design around organizational intelligence (see Liang, 2002; Liebowitz, 1999; McMaster, 1996).

There are various definitions of organizational intelligence, although most definitions include ability of information process or interpretation. We will examine organizational intelligence from a new angle—intelligence as a composite of data, information, knowledge, and wisdom. For that purpose, we need to review the concept of information hierarchy. Traditional classification of different levels of information processing put information related intangible assess into a pyramid, with Data at the bottom and Wisdom at the top (see Figure 1).

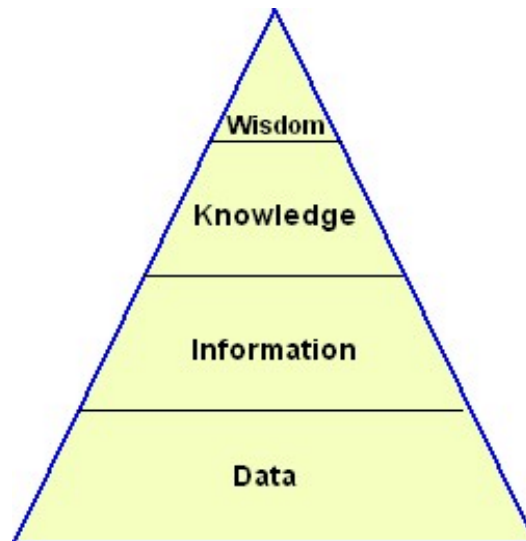


Figure 1. Traditional Information Concept Hierarchy

Data are raw facts and values. In themselves, data have little value. Information is data put into meaningful format (Stair and Reynolds, 2003). Mingers (1997) discussed in details the nature of information and its relationships to meaning. According to Mingers and many other researchers, information is meaningful data or data in context. In this regards, data and information are closely related. It is possible that the same item may be considered data in one context and information in another. However, other researchers believe that data and information are absolutely different. Data are considered objective, the independent variable while information is subjective and the dependent variable (Callaos and Callaos 2002). In the well-known Shannon's equation, information is defined as the negative logarithm of the probability of observing a given datum (Cover and Thomas, 1991).

The concept of knowledge is quite positive and meaningful, but difficult to give a precise definition. The dictionary definition of knowledge is the state of knowing. To know is to grasp in the mind with clarity and certainty. Some also define it as the capacity to act or the understanding gained through experience or study (Allee, 2003). Knowledge is mutable and it takes on many faces in an organization. Unlike data and information, knowledge is closely bound to individuals; it is their set of cognitions and skills for solving problems. From a practitioner's point of view, knowledge is the body of guidelines and procedures used to accomplish a specific task (Stair and Reynolds, 2003).

Wisdom is insight; it is the "understanding of what is true, right, or lasting."¹ Joseph Meeker (1981) defines wisdom as "a state of the human mind characterized by profound understanding and deep insight." At individual level, wisdom is the inner-neural connections that reflex the person's ability of correlating information and knowledge. Knowledge is essential, but not equivalent to wisdom. Wisdom is the knowledge of knowledge, or the meta knowledge. Matthews (1988) considers wisdom the ability to use knowledge in a constructive way. At organizational level, wisdom is the shared knowledge integrated at individual, team, and organizational levels.

¹Excerpted from *The American Heritage Dictionary of the English Language, Third Edition* Copyright © 1992 by Houghton Mifflin Company.

Intelligence is another elusive concept that have generated interesting and, sometimes, heated debate over the years. The difficulty of defining it arises from the fact that it is not a single entity. Intelligence has multiple dimensions that involve awareness, information process, knowledge, and ability. Perkins (1995) classified intelligence into three categories: (1) Neural intelligence which is the brain power rooted in the biological system. (2) Experiential intelligence which is built on learning and experience. It involves “know-how” of accomplishing specific tasks. (3) Reflective intelligence which is based on knowledge of thinking strategies. For our purpose of studying information technology supported organizational intelligence, we will define intelligence as a mental power of effective responding to environmental changes. It is embodied as the right combination of data, information, knowledge and wisdom. Organizational intelligence is the bedrock of intelligent enterprises.

Taxonomy of Intelligence

Intelligence discussed in the previous section belongs to natural intelligence, which is a critical quality of individuals and organizations. Another type of intelligence—artificial intelligence has played a minor, but increasingly significant role in building intelligent organizations. Artificial intelligence is “the part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics we associate with intelligence in human behavior” (Barr and Feigenbaum, 1981). There are many other definitions for artificial intelligence. Computer systems are considered intelligent when they understand languages, learn, reason, and solve problems that require sophisticated analysis. Note that the typical requirement for artificial intelligence is less for natural intelligence. As advance information technology and systems become an integrated part of organizational intelligence, the role of artificial intelligence in intelligence infrastructure will likely increase.

Organizational intelligence is not a simple sum of intelligence of individuals in the organization, although collective intelligence is closely related to the intelligence level and the number of individuals. Most organizational learning literature has dealt with the collective intelligence, recognizing the importance of synergy created by networked individuals. Much less has been studied is the emergent intelligence in an organization.

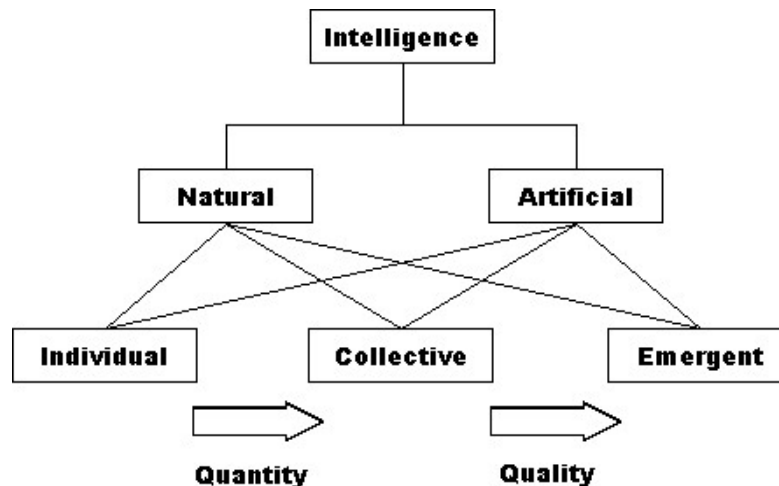


Figure 2. Taxonomy of Intelligence

Emergent intelligence is intelligent behavior that arises spontaneously from the simultaneous interaction of large number of individuals. This type of intelligence has been observed in natural systems such as ant colony. It has been suggested that similar emergent intelligence may be created in human systems. There is scant evidence, for example, that the Internet has shown certain features of emergent intelligence. Note that the change from individual intelligence to collective intelligence is typically quantitative while the change from collective to emergent intelligence is qualitative. By definition, emergent behavior is a system feature that is not possessed by individuals of the system.

Organizational Intelligence

Halal and Kull (1998) define organizational intelligence as “the capacity of an organization to create knowledge and use it to strategically adapt to its environment.” It is similar in purpose to the way IQ is defined in individuals. Glynn (1996) separates organizational intelligence into three categories: (1) the aggregate of individual intelligence, (2) the interrelation of individual intelligence, and (3) intelligence of the organization itself as a larger system. Using the taxonomy given in the previous section, we divide organizational intelligence in the following three levels: individual, collective (including the sum of individual intelligence and added intelligence through small scale interaction), and emergent.

There are two ways to look at information technology supported organizational intelligence. One is to examine the elements or the assets that are essential for intelligent organizations. The other is to examine the processes that are involved in creating, sustaining, and adapting organizational intelligence. Figure 3 shows the levels of organizational intelligence. Intelligence at all levels arises from the integration and interaction of data, information, knowledge, and wisdom of both internal and external sources.

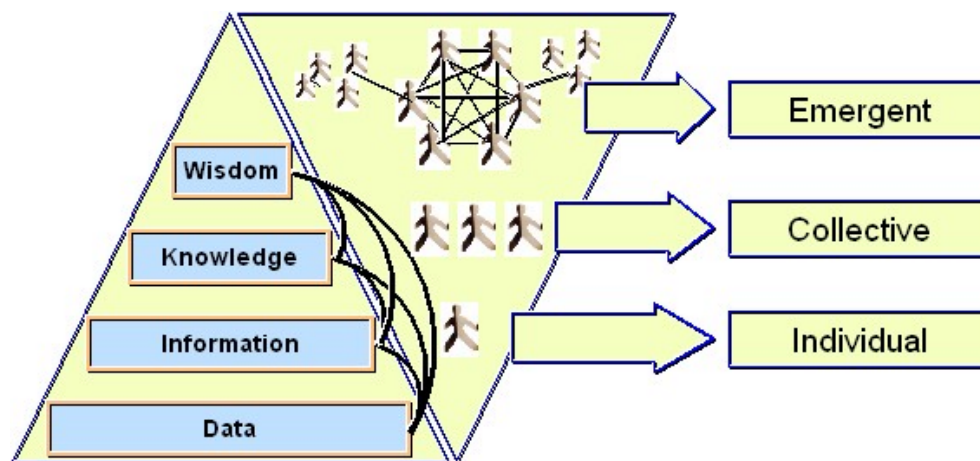


Figure 3. Levels of Organizational Intelligence

Intelligence Infrastructure

Organizational intelligence starts with the intelligence of units and members of the organization. Liang (2001, 2002) studied intelligence characteristics of individuals and how the individual mind sets come to form “orgmind” or collective intelligence. McMaster (1996) defined organizational intelligence as a function of the number of connections, the intricacy of those connections, and system design. Computer networking and communications technologies have greatly enhanced the connectivity of organizations and changed the way they operate.

The evolution of information technology is intertwined with evolution of organizations. Huber (1990) pointed out the need to re-examine theories of organizational design when advanced information and communication technologies have dramatically changed the operations and management of organizations. While there is voluminous research in the impact of information technology on organizations and the integration of various information systems (see Mentzas, 1994; Markus, Majchrzak, and Gasser, 2002), most studies have not considered a comprehensive, totally integrated infrastructure for intelligent organizations. Information systems design theories has traditionally focused on design of specialized systems such as DSS and EIS (Churchman 1979; Walls et al. 1992). As more and more organizations realize the importance of building, nurturing, and growing organizational intelligence, the need for study organizational intelligence infrastructure is inevitable.

An intelligence infrastructure is made possible by adding to the existing information/knowledge systems a set of distributed intelligent agents that greatly enhance the integration, coordination, and collaboration of people and resources in an organization. This built-in intelligence at the infrastructure level makes the organization agile and robust. The evolution of modern organizations and their information infrastructure is depicted in Figure 4. TPS, MIS, DSS, and EIS are traditional business information systems

at different managerial levels. DB and KM are short for database and knowledge management, respectively. Supply chain management (SCM), enterprise resource planning (ERP), business process redesign (BPR), and total quality management (TQM) are commonly used in learning organizations. Multi-agent systems (MAS) enables intelligence infrastructure (II). Global resource management (GRM) and customer relationship management (CRM) are indispensable components of an intelligent enterprise.

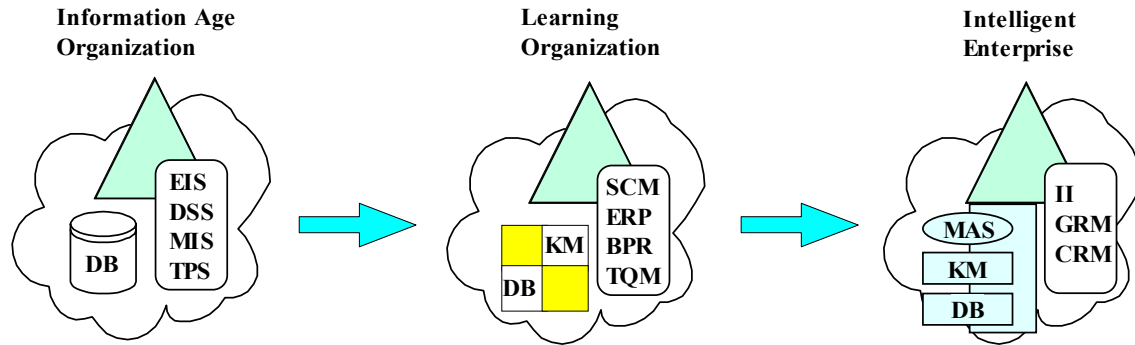


Figure 4. Evolution of Organizations and Their Information Infrastructure

A key feature of the intelligence infrastructure is the integration of all components and subsystems within the enterprise. Those components and subsystems include not only various information and knowledge systems, but also management control, human resource management, and environment management. Intelligent agents automate key operational processes, monitor operations, schedule activities, coordinate tasks, process data, anticipate needs, deliver proactive information and services, negotiate and collaborate with other agents, and intimate with their masters—the knowledge users. What distinguishes intelligence infrastructure from other types of systems is its ability to continuously capture and integrate business process knowledge, hence improving the organization's ability to learn and adapt while the changes occur, not after.

Conclusion

Organizational intelligence has been recognized as vital to intelligent enterprises. An intelligent enterprise is an organic organization that maintains its competitive edge by effectively developing, sustaining, and leveraging its unique knowledge resources that others cannot duplicate. As globalization and competition increase, more and more organizations realize that they need to transform from a traditional, rigid structured organization to an intelligent organization. The key ingredients to a successful intelligent organization are: distributed intelligence, effective knowledge management, self-organizing autonomous units, frictionless access to resources, and organizational learning.

We have proposed to study the intelligence infrastructure as the foundation of organizational intelligence. The intelligence infrastructure can be built by integrating multi-agent systems with traditional information and knowledge systems. The intelligence infrastructure supports and enhances the complex and dynamic functionalities of an intelligent organization. Through open standards and intelligent agents, traditional systems will be able to cooperate and provide coherent information and services to end users. Intelligent agents serve as intermediaries that not only make vast resources available to the users, but also empower the users by automating, consolidating, and simplifying routine tasks, and allowing the users to explore and perform tasks that were not possible in the past.

Computer intelligent agents have been around for many years. It is only recently that they have made significant inroads into real world applications. Although in certain specific areas intelligent agents have been deployed successfully, so far there has been little effort to systematically integrate intelligent agents with traditional information and knowledge systems. Before such an endeavour can begin, more work needs to be devoted to the creation of a solid conceptual framework of intelligence infrastructure. We also need operational definitions of intelligence infrastructure so that it can be designed, implemented, and measured for effectiveness.

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